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the blastoderm comprehends twelve micromeres and twenty macromeres, eight of the former being parted from eight of the micromeres. By this method of parting off micromeres, the latter at the end of segmentation are more than three hundred in number, and form a plaque with the smaller micromeres in the centre. The peripheric zone of the blastoderm occupied by the macromeric segments or blastocones, becomes transformed into a special thin bed which intercalates itself between the embryo and the vitellus, and is called by Vialleton the perivitelline membrane. Meanwhile a division of the micromeres or blastomeres perpendicular to their height produces a deeper layer of cellules—a mesoderm. Thus the egg at this stage consists of: (1) the ectoderm, which forms a circular plate composed in its centre of a single layer of cellules, but around its edge of several layers, produced by delamination at the expense of the superficial layer. (2) Of the mesoderm (*pars*) represented by the deeper beds of the borders of the blastoderm; and (3) by the perivitelline membrane or primitive endoderm. The border of the blastoderm then parts into a clear portion which becomes the vitelline sac, and an interior embryonal area. By secondary determinations, the ectoderm afterwards furnishes additional elements to the mesoderm. The entoderm, usually formed at an early stage, does not show itself in the Sepia until the eyes and pallial folds have been sketched out, and its development is very rapid, and seems to be formed at the expense of the perivitelline membrane.

PSYCHOLOGY.

The Psychic Life of Micro-Organisms.[1]—M. Alfred Binet, one of the most eminent representatives of the French School of Psychology, has presented in the above work the most important results of recent investigations into the world of micro-organisms. The subject is a branch of comparative psychology little known; as the data of this department of natural science lie scattered for the most part in isolated reports and publications, and no attempt has hitherto been made to collate and present them in a systematized form.

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[1] The Psychic Life of Micro-Organisms. A Study in Experimental Psychology. By Charles Binet. Translated from the French by Thomas McCormack, with a preface by the author written especially for the American edition. Chicago: 1889. The Open Court Publishing Company. Cloth, 75 cents. Paper, 50 cents.

M. Binet's researches and conclusions show, "that psychological phenomena begin among the very lowest classes of beings; they are met with in every form of life from the simplest cell to the most complicated organism." The author contests the theory of Prof. George J. Romanes, who assigns the first appearance of the various psychical and mental faculties to different stages or periods in the scale of zoölogical devolopment. To M. Binet mind is an aggregate of properties which exclusively pertain to living matter, the existence of which is seen in the lowest forms of life as well as in the highest.

Prof. Charles Richet contests this view in the *Revue Scientifique*, and maintains with Romanes, that the supposed exhibitions of consciousness in the Protozoa are merely reflexes of protoplasm.

M. Binet finds that the movements of many Protozoa when seeking food display evident design. He thus describes their actions:

"In a large number of animacules the prehension of food is preceded by another stage, the search for food, and in the case of living prey, by its capture. We shall not investigate these phenomena among all the Protozoa, but shall direct our attention especially to the ciliated Infusoria. Their habits are a remarkable study. If a drop of water containing Infusoria be placed under the microscope, organisms are seen swimming rapidly about and traversing the liquid medium in which they are in every direction. Their movements are not simple; the infusory guides itself while swimming about; it avoids obstacles; often it undertakes to force them aside; its movements seemed to be designed to effect an end, which in most instances is the search for food; it approaches certain particles suspended in the liquid, it feels them with its cilia, it goes away and returns, all the while describing a zigzag course similar to the paths of captive fish in aquariums; this latter comparison naturally occurs to the mind. In short, the act of locomotion, as seen in detached Infusoria, exhibits all the marks of voluntary movement.

"The hunter Infusoria are constantly running about in quest of prey; but this constant pursuit is not directed toward one object any more than another. They move rapidly hither and thither, changing their direction every moment, with the part of the body bearing the battery of trichocysts held in advance. When chance has brought them in contact with a victim, they let fly their darts and crush it; at this point of the action they go through certain manœuvres that are prompted by a guiding will. It very seldom happens that the shattered victim remains motionless after direct collision with the mouth of its assailant. The hunter, accordingly, slowly makes his way about the scene of action, turning both right and left in search of his lifeless prey. This search lasts a minute at the most, after which, if not successful in finding his victim, he starts off once more to the chase and resumes his irregular and roving course.

"In constant pursuit of its prey, the *Leucophrys* seizes its victim by the two stout vibratile lips with which its mouth is armed, and swallows them alive and whole. The victims may be seen struggling and tossing about for a time in the interior of the Leucophrys's body, and afterward to expire slowly under the action of the digestive juices of the vacuole in which they have been enclosed. Placed in a medium well-stocked with small Ciliates, the Leucophrys have their bodies constantly crammed with victims swallowed in the manner above described. Like the other hunter Ciliates the Leucophrys does not espy its victims from a distance, and does not guide itself toward them. It simply darts about from right to left, every moment changing its direction. It thus increases its chances of coming in collision with its prey, and every time that one of its unfortunate victims falls in contact with its vibratile lips, it is seized, irresistibly drawn toward the mouth and swallowed within less than a few seconds.

"The prehension of food by the *Didinium* exhibits interesting aspects which have not as yet been observed in any other Infusory. M. Balbiani, in his first observations, had often been surprised at seeing animalcula that the Didinium had passed by without touching, suddenly stop as if violently paralyzed; whereupon our carnivorous specimen straightway approached and seized them with seeming facility. More careful examination of the Didinium's actions soon furnished the key to this enigma. If, while swiftly turning in the water, the Didinium happens in the neighborhood of an animalculum, say a Paramecium, which it is going to capture, it begins by casting at it a quantity of bacillary corpuscles which constitute its pharyngeal armature. The Paramecium immediately stops swimming, and shows no other sign of vitality than feebly to beat the water with its vibratile cilia; on every side of it lie scattered the darts that were used to strike it. Its enemy then approaches and quickly thrusts forth from its mouth an organ shaped like a tongue, relatively long and resembling a transparent cylindrical rod; the free, extended extremity of this rod it fastens on some part of the Paramecium's body. The latter is then gradually brought near by the recession of this tongue-shaped organ toward the buccal aperture of the Didinium, which opens wide, assuming the shape of a vast funnel in which the prey is swallowed up.

"There exist organisms which lead a life of habitual isolation, but which understand how to unite for the purpose of attacking prey at the desired time, thus profiting by the superiority which numbers give. The *Bodo caudatus* is a voracious Flagellate possessed of extraordinary audacity; it combines into troops to attack animacula one hundred times as large as itself, as the Colpods for instance, which are veritable giants when placed alongside of the Bodo. Like a horse attacked by a pack of wolves, the Colpod is soon rendered powerless; twenty, thirty, forty Bodos throw themselves upon him, eviscerate and devour him completely.

All these facts are of primary importance and interest, but it is plain that their interpretation presents difficulties. It may be asked whether the Bodos combine designedly in groups of ten or twenty, understanding that they are more powerful when united than when divided. But it is more probable that voluntary combinations for purposes of attack do not take place among these organisms; that would be to grant them a high mental capacity. We may more readily admit that the meeting of a number of Bodos happens by chance. When one of them begins an attack upon a Colpod, the other animacula lurking in the vicinity dash into the combat to profit by a favorable opportunity.

M. Binet compares the movements of the Protozoa in reproduction with those of the reproductive elements in the higher animals,—the spermatozoid and the ovum. He says:

"A remarkable circumstance in this connection is, that the copulation of the spermatozoöid and ovule is not without analogy to the copulation of the two animals from which they originated. The spermatozoid and the ovule, to some extent, repeat on a small scale what the two individuals perform in their larger sphere. Thus, it is the spermatozoöid that, in its capacity of male element, goes in quest of the female. It possesses, in view of the journeys it has to make, organs of locomotion that are lacking in the female, and are useless to it. The spermatozoöid of man and of a great number of mammifers is equipped with a long tail, the end of which describes a circular conical movement, which, together with its rotation about its axis, determines the forward motion of the spermatozoöid.

"The spermatic element, in directing itself toward the ovule to be fecundated, is animated by the same sexual instinct that directs the parent organism towards its female.

"In the higher animals the movements of the spermatozoöid that is endeavoring to reach the female exhibit a peculiar character which it

PLATE XXXV.

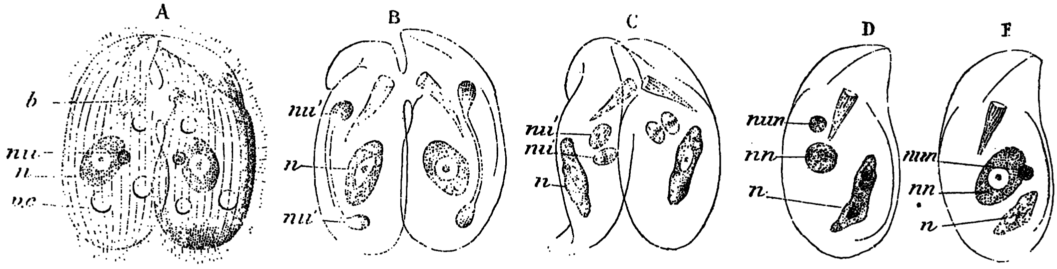

FIG. 1.

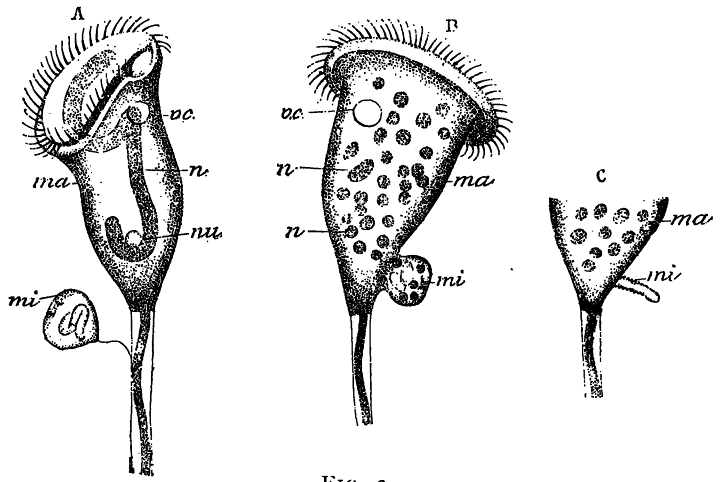

FIG. 3.

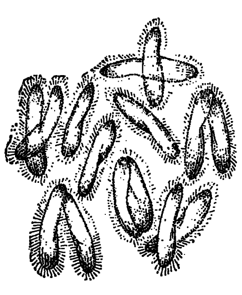

FIG. 2.

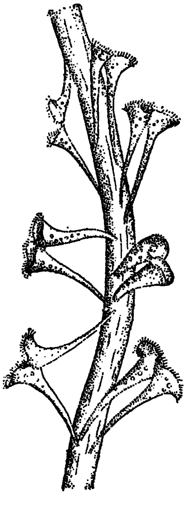

FIG. 4.

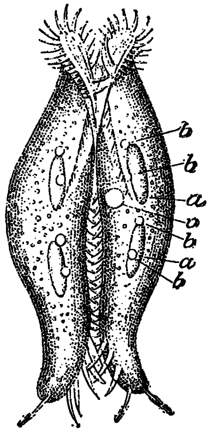

FIG. 5.

is important to emphasize: these movements do not appear to be directly provoked by an exterior object, as those of micro-organisms are; the spermatozoöid endeavors to reach an ovule which is frequently situated a great distance away; this is the case particularly with animals that fecundate internally,—with birds and mammifers. A fact that is important to mention in a general way is the length of road the spermatozoöid has to traverse before coming up with the ovule.

"Let us now follow the spermatozoöid in its journey to the ovule. It is known that the road it has to traverse is, in certain instances, extremely long. Thus in the hen the oviduct measures 60 centimeters, and in large mammifers the passages have a length of from 25 to 30 centimeters. We might ask ourselves how such frail and minute creatures come by a power of locomotion great enough to enable them to traverse so long a path. But observation discloses the fact that they are able to overcome obstacles quite out of proportion to their size. Henle has seen spermatozoöids carry along with them masses of crystals ten times larger than themselves, without appreciably lessening their speed. F. A. Pouchet has seen them carry bunches of from eight to ten blood-globules. M. Balbiani has attested the same fact. These globules, which have fastened themselves about the head of the spermatozoöid, have each of them a volume double that of the head. Now, according to Welcker, the weight of a globule of human blood is 0.00008 of a miligramme: allowing that the spermatozoöid has the same weight, we may then say that it is able to carry burdens four or five times heavier than itself."

EXPLANATION OF PLATE.

Fig. 1. Conjugation of *Chilodon cucullueus*. *A*, beginning of conjugation; *b*, mouth; *n*, nucleus; *nu*, nucleolus; *vc*, multiple contractile vesicles. *B*, division of the nucleolus into two segments, *nu' nu'*; the nucleus *n*, beginning to show signs of regression. *C* each of the two individuals in conjugation contains two nucleolar segments, brought near together, of which one probably comes from the individual opposite by course of exchange, and will fuse with the segment not exchanged to form a compound segment (Maupas). *D*, division of the segment into two portions, which grow to unequal sizes; the larger *nu* will become the new nucleus; the smaller, the new nucleolus of the new formation *nun*. *E*, the old nucleus *n* reduced to a small, pale and rumpled mass, is replaced by the new nucleus *nu*, near by which is seen the new nucleolus *nun*. (From Balbiani.)

Fig. 2. *Paramecium aurelia;* positions preliminary to conjugation.

Fig. 3. Gemmiform conjugation of the vorticellinæ (*Carchesium polypinum*). *A*, firs stage; the microgonidium *nu* has fastened itself by a filament upon the peduncle of the

macrogonidium. *B*, a more advanced stage; the microgonidium has fastened itself directly on the body of the macrogonidium, and its substance begins to penetrate into the latter. In both individuals the nucleus has separated into small rounded fragments, and in the microgonidium are seen the two striated segments resulting from the division of its nucleolus. *C*, last stage of the conjugation. The microgonidium, completely void of its contents, remains attached to the body of the macrogonidium under the form of a minute hollow tube, which in the end drops away;—*ma*, macrogonidium; *mi*, microgonidium; *n*, nucleus; *nu*, nucleolus; *vc*, contractile vesicle. (From Balbiani.)

Fig. 4. *Stentor cœruleus* fixed upon a conferva filament, enlarged fifteen diameters. (From Balbiani.)

Fig. 5. *Stylonychia mytilus*, in position preliminary to copulation. The individuals are in contact by their ventral faces. (From Balbiani.)

MICROSCOPY.[1]

Kultschitzky's[2] Methods of Staining the Central Nervous System.—The tissue, having been hardened in Müller's fluid, or preferably in Erlichi's fluid, imbedded in celloidin, and sectioned, is allowed to remain in the stain from a few minutes to several hours. The first solution of hæmatoxylin is made as follows:

Boracic acid (saturated sol.)	20 ccm.
Water (distilled)	80 ccm.
Hæmatoxylin	1 g.

The hæmatoxylin should be dissolved in a small quantity of alcohol, and then mixed with the boracic acid and water. The resulting fluid will at first be yellow, but in two or three weeks it will change to a dark yellowish red. *Before using, the solution should be acidulated with a small quantity of acetic acid*, two or three drops in a watch-glass being sufficient. After the sections have been in the stain fifteen minutes, the medullated fibres are found to be of a dark violet or blue, while the other elements are of a light yellow or yellowish red. If the sections are allowed to remain longer, from eighteen to twenty-four hours, an intense differential stain results.

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[1] Edited by C. O. Whitman, Clark University, Worcester, Mass.

[2] *Anat. Anzeig.* IV., No. 7, 1889, p. 223.